Long term perspectives for production of fuels from biomass; integrated assessment and RD&D priorities – final results –

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This paper gives the final results of extensive system analyses for a wide range of biofuel production and utilisation options. Analyses are carried out for ?well-to-wheel? systems, including biomass production, logistics, conversion, distribution and end-use. Of particular interest is the time-frame considered: about 20-30 years from now. Such a period of time allows for considerable technology development, installing new (distribution) infrastructure and transportation fleets. Performance and cost estimates are therefore made with this long term perspective in mind. Difference is made between the shorter and longer term performance of biofuel chains for all relevant aspects. Hydrogen and ethanol from wood seen to be superior fuels on the long term and could become cheaper than current gasoline driven vehicles when Fuel Cell Vehicles are applied. Fischer-Tropsch liquids and methanol from wood seem very promising for the shorter and medium tem

Introduction and rationale

Transportation fuels derived from biomass could both reduce the dependency on, imported, oil as well as reduce GreenHouse Gas emissions. When biofuels are applied in new vehicle types like fuel cell powered cars, air pollution of transport can also be dramatically reduced. Disadvantages are the current high(er) costs of biofuels compared to gasoline and diesel and the large land areas which are required for substantial amounts of energy. Both should be minimized to be feasible on longer term.
When considering biofuels it should be noted that a large number of options, energy carriers and complete ?energy-chains? are possible for production and their utilisation. A global overview of the most important options and key performance data derived from the analyses is given in the table.
Most of those (potential) options are not applied commerically at present. Furthermore, they involve technologies and systems which require substantial development over time. Therefore, the timeframe considered is an extremely relevant factor for estimating and analysing potential performance levels of complete chains.
The main objective of this work is to compare all possible major biofuel chains on an equal basis, determine their potential overall performance from an efficiency and economic point of view on shorter and longer term (i.e. 30 years from now) and identify the main uncertainties and Research & Development needs which are essential to obtain the projected performance levels. Analyses are carried out for ?well-to-wheel? systems, including biomass production, logistics, conversion, distribution and end-use

Some main results

Results are expressed in comparable parameters: the calculated costs per GJ fuel delivered at the car and the number of kilometres that can be driven per hectare. For calculating this parameter, various energy inputs were taken into account and translated to primary energy inputs in order to calculate net energy yields. From a cost point of view hydrogen and ethanol from wood seen to be superior fuels on the long term and they could become cheaper than current gasoline driven vehicles when applied in Fuel Cell Vehicles. However, in order to obtain the projected performance for EtOH production from wood a number of technological breakthroughs is required. For hydrogen utilisation, the infrastructure required is the main bottleneck. Fischer-Tropsch liquids and methanol from wood seem very promising for the shorter and medium term.Considering the efficiency and minimizing the amount of land needed for transportation fuels, the high efficiency of FCV?s and hydrogen fueled FCV?s in particular, is decisive. The number of kilometers that can be driven *per hectare* is considerably higher for hydrogen when FCV?s are used. Methanol and ethanol are second best in this respect.

Table. Summary of key data regarding (projected) energetic performance and costs of the conversion systems considered. The capacity of upgrading systems is determined by the output of raw product processed.

Concept	Energy efficiency (HHV) + energy inputs		Investment costs (MU$)		O&M (% inv.)
	Short term (400 MWth)	Long term (1000 MWth)	Short term (400 MWth)	Long term (1000 MWth)	
Hydrogen (compressed)	60% (fuel only)	52% (fuel) 6% (power)	191	363	4
H2 liquefaction	0.19 GJe/GJ H2		19	32	4
Methanol	55% (fuel only)	48% (fuel) 12% (power)	277	526	4
Fischer-Tropsch	43% (fuel only)	40% (fuel) 10% (power	287	544	4
Ethanol (wood)	46% (fuel) 4% (power)	53% (fuel) 8% (power)	141	180	6
Ethanol (sugar)	43% (fuel only) 0.065 GJe + 0.24 GJth/GJ EtOH	43% (fuel only) 0.035 GJe + 0.18 GJth/GJ EtOH	115	173	5
Pyrolysis	60%	70%	415	788	4
Pyrolysis hydrodeoxygenation	67%; 0.025 GJe/GJ output + 0.48 GJ H2/GJ output		140	297	4
HydroThermal Upgrading	78%; 0.01 GJe per GJ output		37	71	4
HTU hydrodeoxygenation	93%; 0.025 GJe + 0.025 GJth + 0.215 GJ H2 per GJ output		210	398	4
Biodiesel RME production	88; 0.01 GJe + 0.04 GJ MeOH per GJ output		60	106	5
Power generation RME	45	55	180	250	4

Some key conclusions

Overall, it seems biofuels can offer a feasible alternative for the transportation sector on the longer term, provided sufficient biomass is available to do so. Wood (or perennial crops in general) seem to be the most favourable feedstock. Ethanol from lignocellulosic biomass, hydrogen, methanol and synthetic hydrocarbons produced via Fischer-Tropsch synthesis seem to be competing amongst eachother, especially on shorter term.

It is interesting to note that the fuel costs on itself only have a modest influence on the overall driving costs of the vehicle types concerned. The investment costs of the car is the dominating factor. Although the annual fuel costs (for a fixed number of kilometers) differs widely depending on the (bio)fuel costs and the vehicle?s efficiency, the overall driving costs do not differ far less between the chains considered. This conclusion is true when taxes (especially on the fuel itself) are excluded. NW European transport fuel markets are however dominated by taxes which increase the production costs of gasoline by a factor of 4-6, depending on the country in question. This also implies that fuel production costs are not that a decisive factor and that on the shorter term fuel taxation policies could play a crucial role in creating markets for biofuels.